Remarks

Favorable reconsideration of this application is requested in view of the following remarks. For the reasons set forth below, Applicant respectfully submits that the claimed invention is allowable over the cited references.

The non-final Office Action dated May 27, 2003, indicated that claims 27-37 and 70 are provisionally elected; the application fails to comply with 35 U.S.C. § 120; the title and abstract are requested to be rewritten as more descriptive; the specification is objected to; claims 28, 37 and 70 are rejected under 35 U.S.C. § 112(1); claims 29-32 are rejected under 35 U.S.C. § 102(b) in view of *Li et al.* (Large Scale Synthesis of Aligned Carbon Nanotubes); claims 29-31, 34 and 35 are rejected under 35 U.S.C. § 102(b) in view of *Kennel* (U.S. Pat. No. 6,156,256); claims 29-32 are rejected under 35 U.S.C. § 102(e) in view of *Xu et al.* (U.S. Pat. No. 5,872,422); claims 34 and 35 are rejected under 35 U.S.C. § 103(a) over *Xu et al.* in view of *Kennel*; claims 34 and 35 are rejected under 35 U.S.C. § 103(a) over *Xu et al.* in view of *Samsung* (EP 1,134,304); and claim 36 is rejected under 35 U.S.C. § 103(a) over *Xu et al.*

The Office Action also indicated the following obviousness-type double patenting rejections: claims 27-33 are rejected in view of claims 38-40 and 42 of U.S. Pat. No. 6,346,189; claims 27, 29-31, 33, 37 and 70 are provisionally rejected in view of claims 16, 17 and 23 of Application Serial No. 10/233,320; claims 27 and 29-35 are provisionally rejected in view of claims 17-23 of Application Serial No. 10/285,304; and claims 29-31 are provisionally rejected in view of claims 9-11 and 22 of Application Serial No. 10/299,945.

Regarding the restriction requirement, Applicant respectfully traverses because the "means" claim, claim 38 is a "linking claim" that links the claims of both groups (Group I and Group II) and, by so linking them, pursuant to the MPEP, these claims are not to be restricted from one another but are to be examined together. In restricting Group I, claims 27-37 and 70, from Group II, claims 38-69, the Office Action, erroneously relies upon a portion of MPEP § 806.05(e) which is superceded. According to § 806.05(e), where a restriction would otherwise be applicable as it pertains to a process and apparatus for its practice, "if the apparatus claims include a claim to "means" for practicing the process, the claim is a linking claim and <u>must</u> be examined with the elected invention." As clearly stated in MPEP § 806.05(e), it is inappropriate to restrict method claims from apparatus

claims where the apparatus claims include a linking claim to "means" for practicing the process:

> Process and Apparatus for Its Practice - Distinctness In applications claiming inventions in different statutory categories, only one-way distinctness is generally needed to support a restriction requirement. See MPEP Section 806.05(c). Process and apparatus for its practice can be shown to be distinct inventions, if either or both of the following can be shown: (1) that the process as claimed can be practiced by another materially different apparatus or by hand, or (2) that the apparatus as claimed can be used to practice another and materially different process. <u>If the apparatus claims include a claim to "means" for practicing the process, the claim is a linking claim and must be examined with the elected invention.</u>

SECTION 806.05(e) (emphasis added).

Moreover, the rationale in support of the restriction is untenable. The Office Action presents this rationale as: "the apparatus as claimed can be used to practice another and materially different process, such as a process of depositing a material <u>other than a carbon nanotube</u> (*e.g.,* other forms of carbon such as a fullerene/ buckyball, graphite, amorphous carbon, etc.)." The instant invention, as set forth in the apparatus claims (*e.g.,* claim 38) is an apparatus that specifically forms a carbon nanotube and, therefore, does not involve or otherwise permit modification so as to practice another and materially different process such as a material other than a carbon nanotube. This relied-upon portion of MPEP § 806.05(e) is directed to more general apparatus claims that can be distinguished from a process without completely changing the claimed invention to make this rule fit. In this regard, paragraph 3 of the Office Action fails to present a tenable rationale in support of the restriction.

In view of the above discussion and the corroborating mandate set forth in the MPEP, Applicant requests that the restriction be withdrawn.

Notwithstanding the above discussion and request to withdraw the restriction, Applicant affirms the election of Group I. Applicant maintains that in this instance, claim 38 is a linking claim tying claims 27-37 and 70 with claims 38-69. Accordingly, the restriction must be removed.

Turning now to the issue of priority under 35 U.S.C. § 120, Applicant respectfully traverses the assertion that the instant application fails to comply with one or more conditions for receiving the benefit of an earlier filing date under 35 U.S.C. § 120. The instant application complies with at least the filing requirements of a continuation-in-part application as set forth in MPEP § 201.08 and, therefore, should be permitted to claim the benefit of the filing date of U.S. Patent 6,346,189 filed on August 14, 1998. The instant application was filed pursuant to 37 C.F.R. § 1.53(b) and complies with the formal requirements (A)-(C) of 35 U.S.C. § 120 as set forth in MPEP § 201.08. First, the application was filed sharing at least one common inventor with the first application, for example, Mr. Hongjie Dai. Second, the application was filed on January 7, 2002, before the patenting of the first application, which occurred on February 12, 2002. Third, the first sentence of the application was amended to contain a specific reference to the earlier filed application and such amendment was referenced in paragraph 5 of the application transmittal. Moreover, upon filing, the application claimed priority for "common subject matter" and was filed under 37 C.F.R. § 1.53(b) (which concerns continuations-in-part applications rather than identical-subject-matter continuations). Thus, because Applicant has fully complied with the requirements of 35 U.S.C. § 120, Applicant submits that this priority-claim issue is moot.

In an effort to more particularly articulate the relationship between the instant application and the above-mentioned parent application, Applicant has amended the first sentence of the instant application to indicate that the instant application is a continuation-in-part of U.S. Application Serial No. 09/133,948, now U.S. Patent 6,346,189. This relationship was already implicitly present because, as mentioned above, the application claimed priority for "common subject matter" and was filed under 37 C.F.R. § 1.53(b). Thus, this amendment does not change the relationship of this application with U.S. Patent 6,346,189 or introduce new matter.

With respect to the discussion of the Abstract and Title, Applicant has amended the Abstract and Title in accordance with the Examiner's suggestions.

Regarding the alleged lack of support for the subject matter of claims 34 and 35, Applicant respectfully traverses the objection to the Specification because pursuant to 35 U.S.C. § 112, the claims are considered part of the specification. Thus, claim language is

part of the Specification. The Board of Patent Appeals and Interferences has held that a claim must be reasonably ascertainable to one skilled in the art, and the MPEP further explains that, with respect to either the claims or the disclosure, word-for-word correspondence is not a requirement for claim language. *See*, *e.g.*, M.P.E.P. § 2173.05(e). Thus, the Specification is therefore inherently in line with claims 34 and 35 because claims 34 and 35 are part of the Specification. Moreover, the detailed description addresses the subject matter of claim 34, for example, in connection with the discussion at the last sentence of page 8 and extending to page 9, line 1. Applicant has also amended the Specification to more expressly align this claimed subject matter with the detailed description, *e.g.*, articulating that the carbon containing gas may be reacted with a catalyst before contacting the catalyst island. Thus, Applicant's Specification is in compliance with 35 U.S.C. § 112 and no further support should be necessary.

Applicant respectfully traverses the Section 112(1) rejection of claims 37 and 70. Contrary to the assertion presented in the Office Action, the Specification clearly describes "the combination of steps" presented in claims 37 and 70. As indicated above, the claim language is part of the Specification. Further, compliance with Section 112 is satisfied because the written description requirement does not require the applicant "to describe exactly the subject matter claimed, [instead] the description must clearly allow persons of ordinary skill in the art to recognize that [he or she] invented what is claimed."" *Union Oil Co. of California v. Atlantic Richfield Co.*, 208 F.3d 989 (Fed. Cir. 2000), *cert. denied*, 69 U.S.L.W. 3165 (Feb. 20, 2001) (No. 00-249) (quoting *In re Gosteli*, 872 F.2d 1008, 1012, 10 U.S.P.Q.2d 1614, 1618 (Fed. Cir. 1989) (citations omitted)); *In re Wertheim*, 541 F.2d 257, 265, 191 U.S.P.Q. 90 (CCPA 1976); MPEP § 2163.02. With that being said, the steps of claim 37 are clearly shown and described in connection with the illustrated figures. Before addressing these steps in detail, reference should be made to the commonly-used reference numerals for like structures in the described example embodiments and to page 6 of the Specification that explains: "The substrate 22 is made of material that may, for example, include one or more of silicon, alumina, quartz, silicon oxide or silicon nitride, and in one implementation, includes a metal film on the top surface." Thus, for each such type of described embodiment, the substrate 22 is taught as various example embodiments, some of which may include a

metal film on the top surface. With this understanding that a layer of conductive material is formed on the insulative substrate, Figure 9 is shown and described in line with claim 37 as follows: etching a trench (35) in the layer of conductive material (top surface of substrate 22) and, per page 12, lines 1-3 of the Specification, exposing the insulative substrate (22) at the bottom of the trench (35); forming catalyst material (29) on portions of the layer of conductive material at opposing sides of the trench (35); and, as discussed throughout the Specification, heating the substrate (while introducing a carbon feedstock gas to the catalyst material and growing an aligned carbon nanotube extending from the catalyst material and across the trench (35). Claim 70 (dependent upon claim 37) is directed to the step of etching the trench as discussed above in connection with claim 37. Thus, Applicant respectfully requests that this rejection also be removed.

Applicant similarly traverses the rejection under Section 112(1) rejection of claim 28. The Specification discusses this aspect of the claimed invention at page 14 in connection with Figures 13A-13D, stating for example, "An electric field is then applied between the tip 47 and the gold film 52. The electric field adheres the $Fe(NO_3)_3$ particle to the tip 47. In one implementation, the electric field also causes the $Fe(NO_3)_3$ to decompose into Fe_2O_3." It would be appreciated that the "contacting ..." and "applying ..." steps set forth in claim 28 can occur concurrently. Applicant respectfully requests that this rejection also be removed.

Applicant respectfully traverses the Section 102(b) rejection of claims 29-32, because the article by *Li et al.* fails to correspond to the claimed invention. Throughout *Li's* article, each embodiment contemplates the nanoparticles being located within the pores and surrounded on its sides by the silica substrate. Moreover, *Li* teaches at page 2 that iron oxide particles are *embedded* in the pores of a silica substrate and reduced to obtain iron nanoparticles, such reduction resulting in the nanoparticles falling *deeper* into the pores of the mesoporous silica (shown in Fig. 4). Even with respect to *Li's* Figure 4 discussion, the "possible" carbon nanotube marked "C" is possibly formed on an upper surface of a nanoparticle (upper surface being exposed via the top of the pore) that is buried in and surrounded by the pore-defining silica substrate. On the contrary, each of claims 29-32 are limited, *inter alia*, forming a catalyst material *island*, wherein the term *island* is used throughout the Specification, and consistent with its normal and expected

meaning in the fields of such nanoprocessing, to refer to an isolated particle accessible from surrounding sides. Interpreting *island* in a manner inconsistent with this common meaning (*i.e.*, an isolated particle not accessible from surrounding sides) would distort the use of this term and render the claims meaningless relative to the example embodiments provided in the supporting Specification. The expected meaning and use of this term island tracks since an *island* is defined and refers to something which is accessible from surrounding sides. For example uses of this term in related nanoprocessing fields, reference may be made to, among others, U.S. Patents: No. 6,610,996 entitled "Semiconductor device using a semiconductor film having substantially no grain boundary" (see Fig. 1c referring to islands 106 and 107); No. 6,610,602 entitled "Magnetic field sensor and method for manufacturing same using a self-organizing polymer mask" (see Fig. 2c referring to island 208); No. 6,602,744 entitled "Process for fabricating thin film semiconductor device" (see Figures and related discussion with *islands* throughout); No. 6,585,947 entitled "Method for producing silicon nanoparticles" (see island in Figure 19a); and No. 6,403,321 entitled "Nano-devices using block-copolymers" (*see Figures 2a-2c)*. Not surprisingly, in each of these and many other occurrences of this term *island*, the meaning is the same as used in the instant Specification (including the subject claims).

Accordingly, by interpreting this claim term in view of Specification (as required by MPEP § 2173.02) or as would be interpreted by those skilled in the art, Li cannot be used to support a Section 102 rejection of claims 29-32. Applicant respectfully submits that the rejection should be removed.

Applicant respectfully traverses the remaining "other-art" rejections (excepting the double-patenting rejection) under §§ 102 and 103(a). These remaining other-art rejections include the rejections of: claims 29-31, 34 and 35 under § 102(b) in view of *Kennel* (U.S. Pat. No. 6,156,256); claims 29-32 under § 102(e) in view of *Xu et al.* (U.S. Pat. No. 5,872,422); claims 34 and 35 under § 103(a) over *Xu et al.* in view of *Kennel*; claims 34 and 35 under § 103(a) over *Xu et al.* in view of *Samsung* (EP 1,134,304); and claim 36 is rejected under 35 U.S.C. § 103(a) over *Xu et al.*

With respect to each of these other-art rejection involving and based on *Xu et al.* (and also *Kennel*), Applicant's traversal is based on the now well-accepted fact that carbon

nanotubes are not the same as carbon fibers, and Kennel's misuse of this terminology (*Kennel* at column 1, lines 5-8) is clearly evidenced by the more recent research as published in more recent journals as well as by the authoritative references authored and edited by *Dresselhaus*. (*see, e.g.*, <u>Carbon Nanotubes: Synthesis, Structure, Properties and Applications</u> (*Dresselhaus, January 2001*).

The carbon fibers discussed in each of these references fail to correspond to the claimed carbon nanotubes as a carbon fiber is not the same as a carbon nanotube.

As defined by their distinct properties, a carbon fiber is not the same as a carbon nanotube. For example, the fiber emitters discussed on lines 18-30 of column 9 in the '422 reference, as with carbon-based fibers in general, include a variety of structures and compositions. As known in the art, however, carbon fibers have properties that are distinctly different from those of carbon nanotubes (*see, e.g.*, the above-mentioned *Dresselhaus* reference). As discussed on page 19 of the *Dresselhaus* reference, "the flexibility of single wall carbon nanotubes and the good mechanical properties of multiwall nanotubes (with only a few walls) under compression, [are] in contrast with carbon fibers which fracture easily under compressive stress along the fiber axis." The '422 reference does not teach any use of carbon nanotubes, and a carbon fiber such as Item 20 of Figure 1 is not the same as a carbon nanotube.

Applicant's review of the '422 Xu reference fails to produce any mention whatsoever of carbon nanotubes, and the '422 reference is <u>*not*</u> directed to a carbon nanotube. The column 9 citations in the '422 patent merely indicate that "The fiber structures can have a variety of morphologies …." For each such morphology, the basic recipe for its manufacture is a recipe for manufacturing a fiber structure and which recipe cannot be used to manufacture a carbon nanotube. Note, for example, each of the '422 patent's fiber growth methodologies are all common to fiber structures, and none of the '422 patent's fiber growth methodologies are directed to growing carbon nanotubes. Accordingly, the '422 patent is not an enabling reference and therefore cannot be used to anticipate Applicant's claimed invention. *See, e.g., Akzo N.V. v. U.S. Int'l Trade Comm'n*, 808 F.2d 1471, 1 U.S.P.Q.2d 1241 (Fed. Cir. 1986). Applicant submits that there is no evidence in the record that would lend support to the argument that a skilled artisan would interpret the '422 patent's nanofibers as the claimed carbon nanotubes, and

the above-referenced *Dresselhaus* reference also clearly lies the foundation for this field by plainly distinguishing carbon nanotubes from carbon nanofibers. Carbon fibers, including nanofibers, are thus distinctly different than carbon nanotubes.

With respect to the §§102 and 103 rejections relying upon *Kennel*, Applicant similarly traverses because *Kennel* also fails to teach the claimed invention involving carbon nanotubes (and similarly fails to enable any process or system for providing the claimed carbon nanotubes). Both the '256 and '422 references are directed to carbon fibers. Although the background portion of the *Kennel* '256 reference discusses carbon nanotubes (erroneously at that), the purpose of the disclosed embodiment of this reference is unequivocally expressed by *Kennel* as overcoming problems in the manufacture of *carbon fibers*; thus, at column 1, lines 44-48, *Kennel* states: "However, these methods are not effective for producing significant quantities of nanofibers." After this initial discussion, *Kennel* fails to either mention, discuss properties of, or enable the manufacture of a carbon nanotube.

With each of these remaining other-art (§§ 102 and 103) rejections relying on this erroneous interpretation and identity between these distinguishable structures, Applicant therefore submits that each of the remaining §§ 102 and 103 rejections is improper.

Regarding the double-patenting rejection of claims 27-33, Applicant has enclosed a terminal disclaimer which is believed to overcome the rejection.

With respect to the provisional double-patenting rejections of claims 27, 29-35, 37 and 70 in view of copending Application Nos. 10/233,320 (STFD.038PA); 10/285,304 (STFD.052PA); 10/299,945 (STFD.053PA); Applicant has duly noted the Examiner's provisional rejections and will proceed accordingly. However, at this time these allegedly duplicative claims of the other pending cases have not yet been allowed and pursuant to the guidelines set forth in the MPEP § 804 (with the "provisional" double patenting rejection being the only rejection remaining) the provisional double patenting rejection should be withdrawn and the application should be permitted to issue as a patent. Accordingly, Applicant would appropriately address the merits of such a rejection once the claims have been allowed in one or all of these other pending cases.

With respect to the concerns raised in paragraphs 40 and 41 of the Office Action, Applicant expressly asserts that each of the copending applications is commonly owned by the same assignee of the instant application at the time the instant application was filed; this common assignee being Stanford University (*a.k.a.*, The Board of Trustees of the Leland Stanford Junior University).

Consistent with the above discussion, Applicant also traverses the characterization of the art made of record but not relied upon in the Conclusion section of the Office Action. However, because this art was not used in connection with any of the rejections, Applicant submits that any such mischaracterization is moot and would require no further discussion.

In view of the remarks above, Applicant believes that each of the rejections has been overcome and the application is in condition for allowance. Should there be any remaining issues that could be readily addressed over the telephone, the Examiner is encouraged to contact the undersigned at (651) 686-6633.

Respectfully submitted,

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Dated: August 26, 2003

By: ____________________
Robert J. Crawford
Reg. No. 32,122

Enclosed: Carbon Nanotubes: Synthesis, Structure, Properties and Applications, pp. 19-20; and Terminal Disclaimer.

do

por-Grown Carbon Fibers (VGCF):
treatment to 3000°C [1]. The mor-
s are shown in (c) for a "PAC-man"
raight graphene ribbons and a miss-
al arrangement of graphene planes.
ntial arrangement of ribbons in the
ore

ear a close resemblance to carbon
tment to about 3000°C, the outer
form facets (Fig. 3b), and become
interplanar correlations resulting
of a vapor grown carbon fiber is
n nanotube (MWNT), as shown in
n fracturing a vapor grown carbon
apor grown carbon fibers (Fig. 3b)
crystal structure and properties.
e pitch-based fibers, are exploited
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adjacent graphene layers, while the
d to defects in the structure. These
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ath failure mode (Fig. 5) that dom-
bon fiber [1]. Typical diameters for
$\sim 7\mu m$, and they can be very long.
led tows and are then wound up as
arkable high strength and modulus
for most of the commercial interest

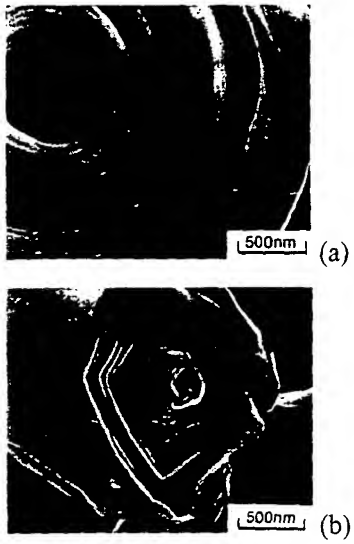

Fig. 4. (a) Carbon nanotube exposed on the breakage edge of a vapor grown carbon fiber as grown (a) and heat-treated at 3000°C (b). The sample is fractured by pulverization and the core diameter is ~ 5 nm. (b) These photos suggest a structural discontinuity between the nanotube core of the fiber and the outer carbon layers deposited by chemical vapor deposition techniques. The photos show the strong mechanical properties of the nanotube core which maintain its form after breakage of the periphery [26]

Fig. 5. The sword-in-sheath failure mode of heat treated vapor grown carbon fibers. Such failure modes are also observed in multiwall carbon nanotubes [1]

in these fibers and these superior mechanical properties (modulus and tensile strength) should be compared to steel, for which typical strengths and bulk modulus values are 1.4 and 207 GPa, respectively [1]. The excellent mechanical properties of carbon nanotubes are closely related to the excellent mechanical properties of carbon fibers, though notable differences in behavior are also found, such as the flexibility of single wall carbon nanotubes and the good mechanical properties of multiwall nanotubes (with only a few walls) under compression, in contrast with carbon fibers which fracture easily under compressive stress along the fiber axis.

Vapor-grown carbon fibers can be prepared over a wide range of diameters (from ~ 10 nm to more than $100\mu m$) and these fibers have central hollow cores. A distinction is made between vapor grown carbon fibers and fibers

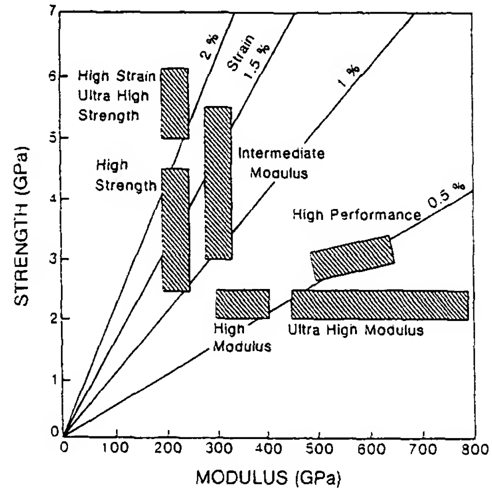

Fig. 6. The breaking strength of various types of carbon fibers plotted as a function of Young's modulus. Lines of constant strain can be used to estimate the breaking strains [1,27,28]

with diameters in the range 10–100 nm, which are called *nanofibers*, and exhibit properties intermediate between those of typical vapor grown carbon fibers, on the one hand, and MWNTs, on the other [24]. The preparation of vapor grown carbon fibers is based on the growth of a thin hollow tube of about 100 nm diameter (a nanofiber) by a catalytic process based on ultra-fine particles (~10 nm diameter) which have been super-saturated with carbon from the pyrolysis of a hydrocarbon gas at ~1050°C [1,29]. The thickening of the vapor-grown carbon fiber occurs through an epitaxial growth process, whereby the hydrocarbon gas is dehydrogenated at the ~1050°C growth temperature, and the carbon deposit is adsorbed on the surface of the growing fiber. Subsequent heat treatment to ~2500°C anneals the disordered carbon deposit and results in vapor grown carbon fibers with a tree ring coaxial cylinder morphology [29]. Further heat treatment to 2900°C results in faceted fibers (Fig. 3b) which exhibit structural and electronic properties very close to those of single crystal graphite [1,29]. If the growth process is stopped before the thickening step starts, MWNTs are obtained [30].

These vapor grown carbon fibers show (h, k, l) X-ray diffraction lines indicative of the 3D graphite structure and a semimetallic band overlap and carrier density similar to 3D graphite. The infrared and Raman spectra are essentially the same as that of 3D graphite. Vapor-grown carbon fibers and nanofibers with micrometer and several tens of nanometer diameters, respectively, provide intermediate materials between conventional mesophase pitch-derived carbon fibers (see Fig. 3) and single wall carbon nanotubes. Since their smallest diameters (~10 nm) are too large to observe significant quantum confinement effects, it would be difficult to observe band gaps in their electronic structure, or the radial breathing mode in their phonon spectra. Yet subtle differences are expected between nanofiber transport properties, electronic